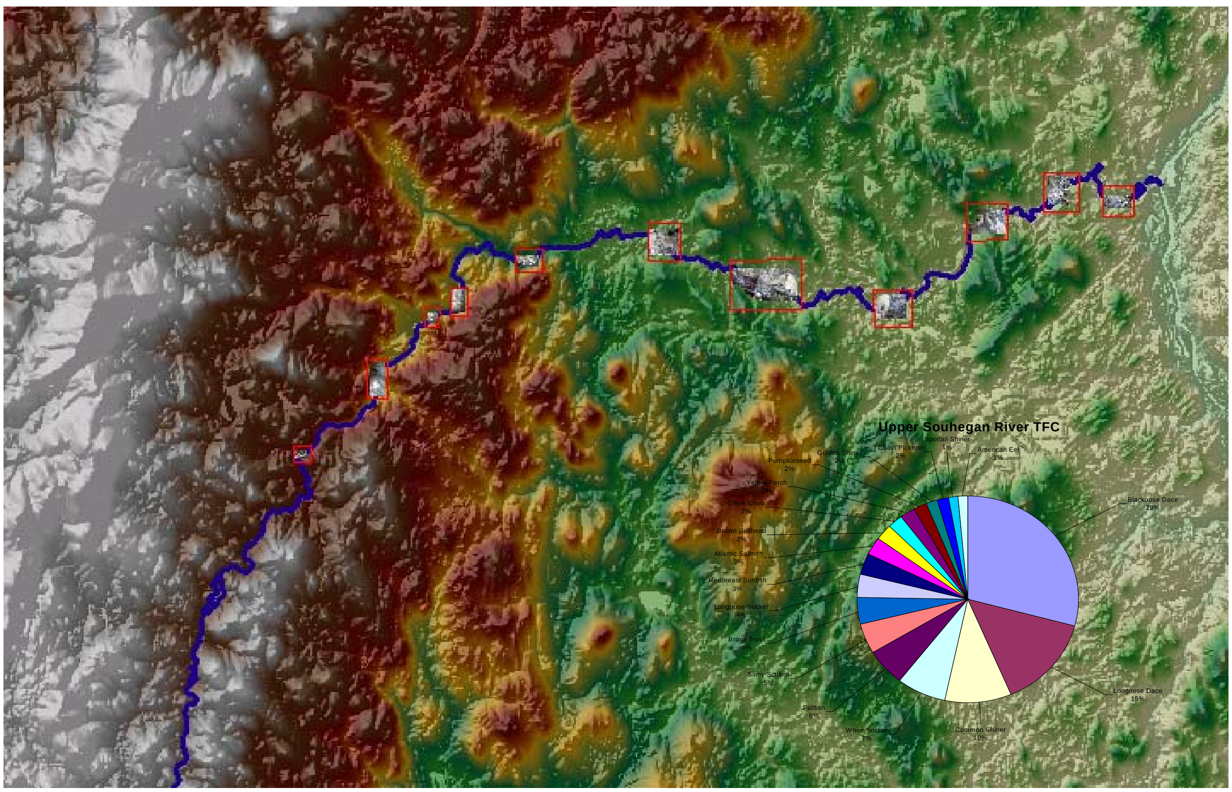
# Target Fish Community Development for the Upper and Lower Souhegan River, New Hampshire

## Draft Summary Report

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## Introduction

The Target Fish Community (TFC) approach developed by Bain & Meixler (2000) allows for the evaluation of the status of the river based on a comparison between the current fish community and a regional model of the desired fish community. The TFC is developed using historical fisheries data from several high quality rivers similar to the investigated one. Its computational framework accounts for spatial and temporal variations of the native community and creates a robust, inter-annual representation of the expected native fauna composition at the watershed scale. Within the MesoHABSIM framework (Parasiewicz, 2001) we use TFC as a biological template providing guidelines for the identification of habitat types necessary to support target fauna.

Developing a TFC model consists of two steps: 1) development of a list of species expected in the river, and 2) computation of the proportion of these species in the native community. The results of step 1 have been presented in the first Instream Protected Uses, Outstanding Characteristics, and Resources (IPUOCR) of the Souhegan River and Proposed Protective Flow Measures for Flow Dependent Resources report (NAI, 2004). This report is a working document for the completion of step 2, consisting of 1) calculation of the TFC model; and 2) a workshop with experts for reviewing the results and determining the final structure of the TFC.

The resulting TFC is compared to the existing fish community model (XFC) generated using fish capture data from the river of study. Both models are compared to habitat mappings of the study river, allowing for the determination of the amount of essential habitats that are presently available for the native fauna of the target community. When combined with MesoHABSIM modeling, the TFC model provides the information necessary to make determinations regarding instream flow requirements necessary to support such habitat types.

We present here two target fish communities, created for portions of the Souhegan River, New Hampshire, to be reviewed by a committee of fisheries experts. The development process is outlined and the resulting communities are offered for assessment. When it is determined that the resulting TFCs are indeed accurate representations of desired fish communities, the TFCs will be compared with the

Souhegan River XFCs and modeled within MesoHABSIM to assess the availability of essential habitats.

## Methods

### *Study Area*

The study area encompasses the main stem of the 171 square mile Souhegan River watershed from the Massachusetts-New Hampshire border downstream (north-northeast) to its confluence with the Merrimack River in Merrimack, New Hampshire. Based on an initial reconnaissance survey and MesoHABSIM habitat mapping of the river in 2004, the river was divided into eleven representative sites (Figure 1). In the area below site 5, the river exhibits multiple geo-physical differences (e.g. stream order, gradient, dominant substrate type) from the river above that point. At the confluence of Stoney Brook (just above site 5) the stream order of the river changes from third to fourth order, the valley begins to widen, and the gradient of the river becomes less steep (Figure 2). There is also a noticeable change in the dominant substrate type in the river below this point, from large cobble and boulders with bedrock outcrops, to sand and fine gravel. These sudden changes in gradient, stream order, and dominant substrate type coincide with the approximate location of the Milford-Souhegan glacial-drift aquifer, an area of unconsolidated glacial-drift deposits consisting primarily of stratified sand and gravel overlain by more recent alluvium (Harte, 1992). The combined effects of gradient and stream order changes, and the sudden change in surficial geology, causing a drastic change in the dominant substrate type creates a difference in the available habitat types between the upper and lower portions of the river. To account for the expected difference in the fish communities associated with these different habitat types, separate TFCs will be developed for the upper and lower Souhegan River.

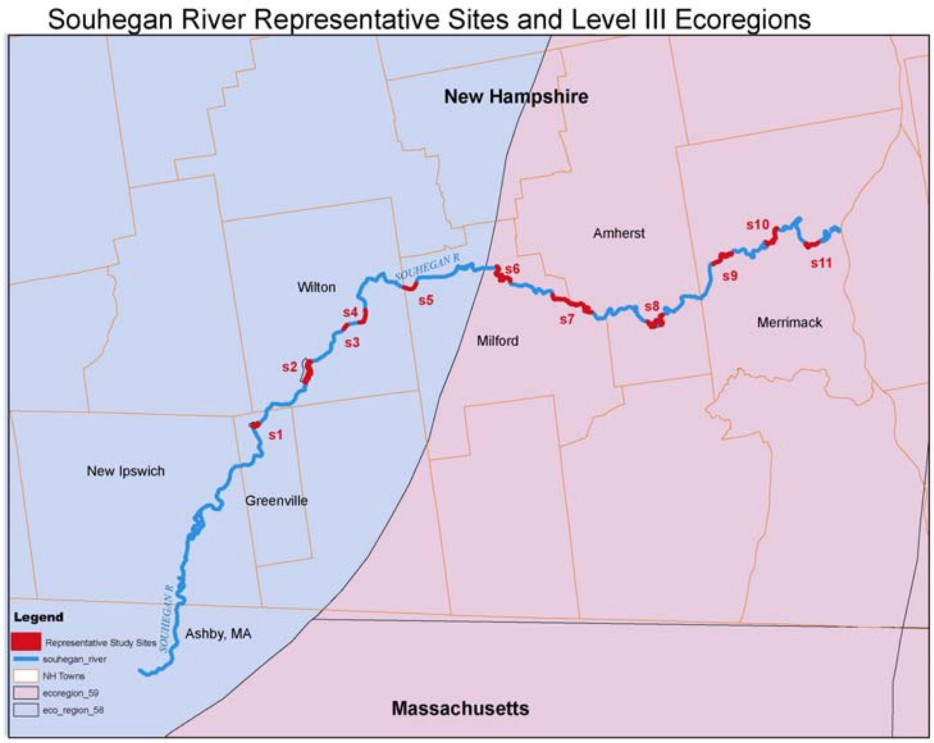


Figure 1. Souhegan River with representative sites and Level III Ecoregions

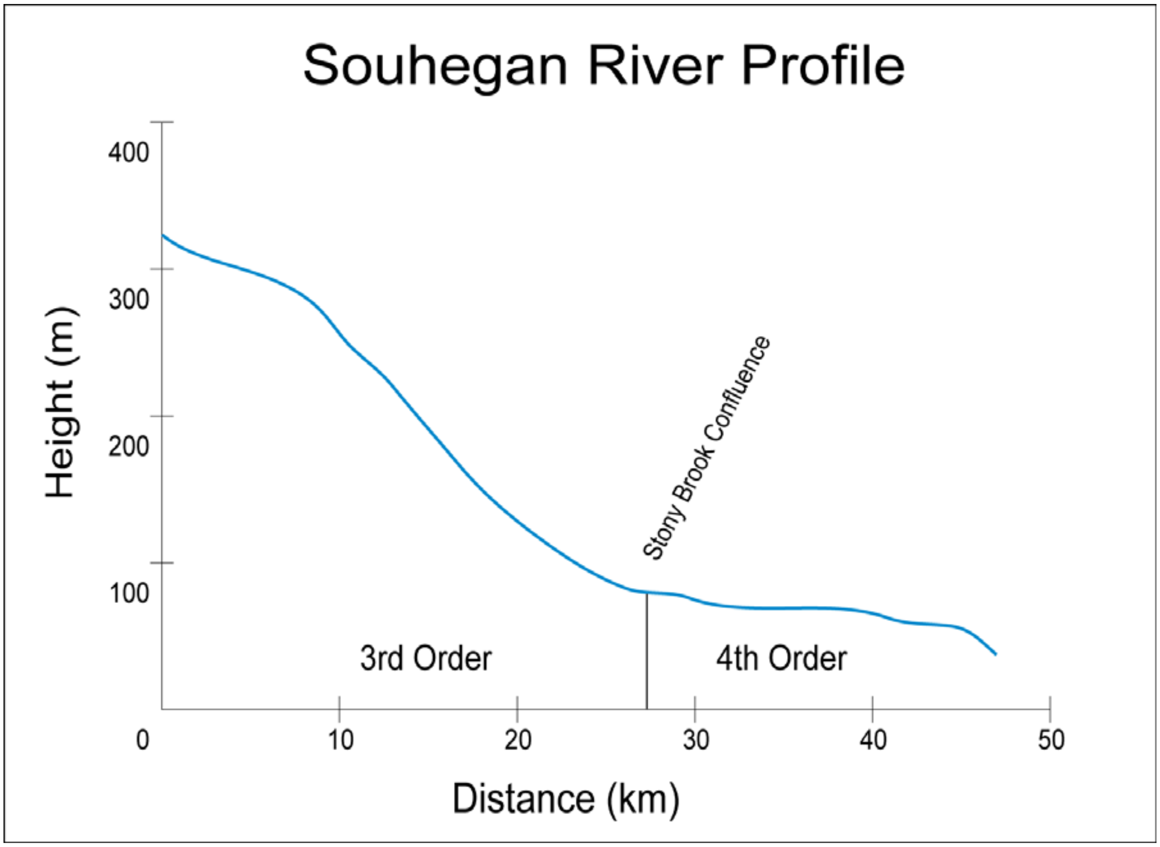


Figure 2. Profile graphic illustrating the gradient of the Souhegan River and identifying the location of the confluence of Stoney Brook.

***Reference River Selection***

In order to establish a TFC that would be representative of the fish community one would desire to develop for the Souhegan River, rivers that were considered to be of similar physical and geographic character to the Souhegan, and in good ecological health were chosen for reference. Historical data of fish found in these rivers were used for the calculation of TFCs for the Souhegan River.

Initial selection of these rivers was made using ArcMap (ESRI, Inc., 1999-2004) GIS software tools. Within Arc GIS, a script was written to select rivers, based on five defined attributes and their parameters (square miles of drainage area, stream order, gradient class, elevation class, and percent of calcareous geologic formations) and Level III Ecoregion (Omernik, 1987[1]). The upper portions of the Souhegan River were within Ecoregion 58, the Northeastern Highlands, and the lower portions of the river extend into Ecoregion 59, the Northeastern Coastal Zone (Figure 1). This further justified development of two different communities for upper and lower portions of the river. The quantitative parameters of these attributes were set to match those of the Souhegan River (Table 1) and the script was applied to a stream classification data layer created by The Nature Conservancy (TNC) (TNC, 2003) to select those rivers meeting the defined criteria.

[1] **Determination of the zoogeographic similarity of areas is based on an analysis of geology, physiography, vegetation, climate, soils, land use, wildlife and hydrology to identify ecologically similar regions, or Ecoregions**

Table 1. Selection criteria of physically similar rivers for the upper and lower portions of the Souhegan River.

**Lower Souhegan River**

| Physical Attribute | Selection Parameters |
|---|---|
| **Drainage Area** | 80-171 sq. miles |
| **Stream Order** | 4 |
| **Gradient Class*** | 1 |
| **Elevation Class**** | 1 |
| **% Calcareous Geology** | 0 |
| **Level III Ecoregion** | 59 |

**Upper Souhegan River**

| Physical Attribute | Selection Parameters |
|---|---|
| **Drainage Area** | 7-80 sq. miles |
| **Stream Order** | 2-3 |
| **Gradient Class** | 1-2 |
| **Elevation Class** | 1-2 |
| **% Calcareous Geology** | 0 |
| **Level III Ecoregion** | 58 |

*Gradient Classes: 1 = 0-0.5%, 2 = 0.5-2%, 3 = 2-4%, 4 = 4-10%, 5 = >10%
**Elevation Classes: 1 = 0-800ft., 2 = 800-1700ft., 3 = 1700-2500ft., 4 = 2500ft.+

The final decision of the suitability of a river to be used as a reference for the project river is based on a determination of the ecological status of the physically and zoo-geographically similar rivers[2]. Using the definition of Kearns et al. (2004), the ecological status of the selected rivers was assessed by judgments of natural resource and fisheries professionals. Rivers that were found to be of poor ecological quality were deemed “impacted” and eliminated from consideration as potential reference rivers. Available fish collection data (having more than 10 individuals of the most common specie in the sample (Bain & Meixler, 2000) from the remaining quality rivers were gathered and used in the development of both TFCs. Table 2 lists all potential reference rivers found to be physically and zoo-geographically similar to the upper Souhegan River and lower Souhegan River and gives reasons for those that were rejected.

[2] **In a similar analysis on the Housatonic River (Kearns et al. 2004), quality rivers were defined as being “relatively unimpaired, undammed, and undeveloped with few water withdrawals, good water quality, and a similar temperature regime.”**

Table 2. The list of rivers identified as physically and zoo-geographically similar to the Souhegan River (potential reference rivers) and reasons for elimination.

| **Upper Souhegan Reference rivers** | **Selected as Reference river** | **Reason for rejection** |
|---|---|---|
| Ashuelot River, SB | No | Impacted |
| Blackwater River, NH | No | Lack of fish data |
| Burnshirt River, MA | Yes | -- |
| Chickley River, MA | Yes | -- |
| Cold River, MA | Yes | -- |
| Contoocook River, North Branch, NH | No | Impacted |
| Cocheco River, NH | No | Impacted |
| Indian River, NH | No | Lack of fish data |
| Mascoma River, NH | Yes | -- |
| Piscataquog River, Middle Branch, NH | Yes | -- |
| Piscataquog River, South Branch, NH | Yes | -- |
| Soucook River, NH | No | Insufficient fish data |
| Sugar River, North Branch, NH | No | Lack of fish data |
| Suncook River, NH | Yes | -- |
| Swift River, East Branch, MA | Yes | -- |
| Westfield River, East Branch, MA | Yes | -- |
| Westfield River, Middle Branch, MA | Yes | -- |
| Westfield River, West Branch, MA | Yes | -- |

| **Lower Souhegan Reference rivers** | **Selected as Reference river** | **Reason for rejection** |
|---|---|---|
| Assebet River, MA | No | Impacted |
| Burnshirt River, MA | No | Insufficient fish data |
| Charles River, MA | No | Impacted |
| Neponset River, MA | No | Impacted |
| Quaboag River, MA | Yes | -- |
| Quinnebaug, River, MA & CT | No | Impacted |
| Quinnipiac River, CT | Yes | -- |
| Soucook River, NH | Yes | -- |
| Suncook River, NH | No | Insufficient fish data |
| Taunton River, MA | No | Impacted |
| Ware River, MA | Yes | -- |
| Willimantic River, CT | Yes | -- |

***Target Fish Community Development***

The fish data used to develop the TFCs were collected by: the New Hampshire Department of Environmental Services (NHDES), the New Hampshire Department of Fish and Game (NHDFG), and the Massachusetts Division of Fisheries and Wildlife (MDFW). Geographic coordinates of the fish-data sample sites were superimposed over the selected portions of the reference rivers within Arc GIS. Maps were then generated showing the locations of these sampling sites within those selected reference rivers from which fish collection data were used in TFC development. Fish data that did not originate from selected suitable portions of the reference rivers were not considered in the formation of the TFC; nor were samples found to have insufficient data (having less 10 individuals collected of the most abundant specie within a sample).

Expected proportions of fish species were generated using the method developed by Bain & Meixler (2000). The total number of fish at each site was summed and the totals of each species were divided by this sum, yielding a proportion of the total catch. These species proportions were summed for all sites and the sums of the proportions then ranked with the species having the greatest sum ranked “1”. All non-native fish species were removed from the data sets prior to calculations of expected proportions. Despite the removal of these species, all of the remaining species maintained the same numerical rank. Next, the reciprocal of each species rank (1/rank) was taken and all of these reciprocals were summed. The reciprocal rank of each individual species was then divided by the total sum of all reciprocal ranks to determine the expected proportion of each individual species.

## Results

***Upper Souhegan River***

The Upper Souhegan River TFC (U-TFC) was created using fish collection data from the eleven quality upper reference rivers identified in Table 2. The resulting community was a diverse one dominated by fluvial species. The ten most abundant species in the U-TFC were blacknose dace (29%), longnose dace (15%), common shiner

(10%), common white sucker (7%), fallfish (6%), slimy sculpin (5%), Eastern brook trout (4%), longnose sucker (4%), redbreast sunfish (3%), and Atlantic salmon (3%). The remaining species consisted of brown bullhead, creek chub, yellow perch, pumpkinseed sunfish, golden shiner, Eastern chain pickerel, spottail shiner, and American eel, and accounted for a combined total of 14% of the expected community. A chart representing the U-TFC is shown in Figure 3. The final species list, mean ranks, and expected proportions of the U-TFC are presented in Table 3.

***Lower Souhegan River***

The Lower Souhegan River TFC (L-TFC) was created using fish collection data from the five quality lower reference rivers also identified in Table 2. The L-TFC is as equally diverse as the U-TFC and is also dominated by fluvial species. The ten most abundant species in the L-TFC were common white sucker (30%), fallfish (15%), common shiner (10%), blacknose dace (8%), longnose dace (6%), yellow perch (5%), pumpkinseed sunfish (4%), brown bullhead (3%), tessellated darter (3%), and Eastern chain pickerel (3%). The remaining species, redbreast sunfish, golden shiner, creek chubsucker, American eel, spottail shiner, margined madtom, and Eastern brook trout, account for a combined total of 12% of the expected community (Figure 4). The data used to generate these figures, including mean ranks and expected proportions, is displayed as Table 4.

Figure 3. Upper Souhegan River Target Fish Community (U-TFC).

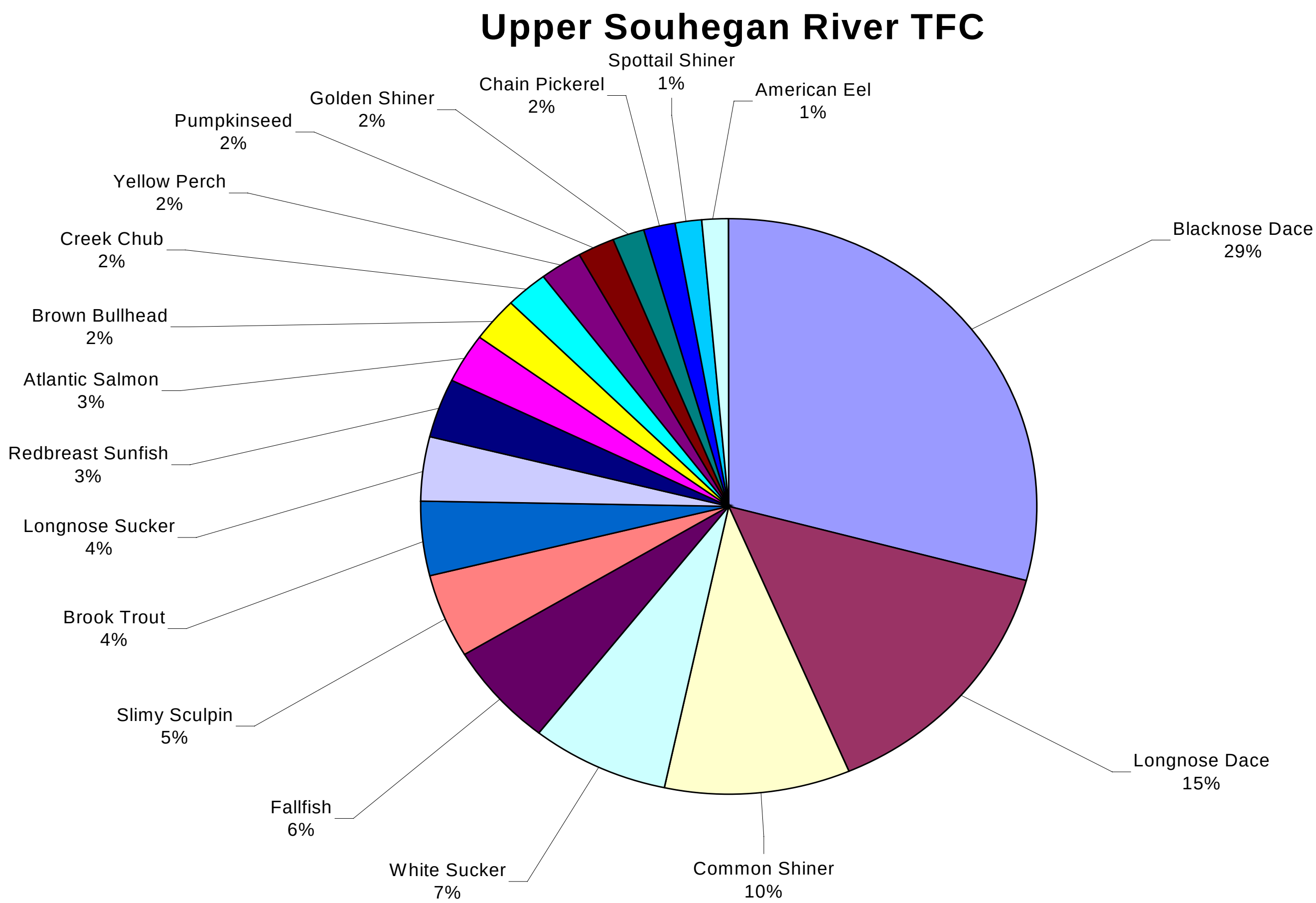

Table 3. Fish captures in reference rivers used for development of Target Fish Community for Upper Souhegan River with calculated mean ranks and expected proportions.

| Common Name | Species Name | Burnshirt River | Chickley River | Cold River | Mascoma River | Piscataquog River, MB | Piscataquog River, S.B. | Suncook River | Swift River, E.B. | Westfield River, E.B. | Westfield River, M.B. | Westfield River, W.B. | Mean Rank | Expected Proportion |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Blacknose Dace | *Rhinichthys atratulus* | 4 | 54 | 159 | 24 | 89 | 138 | 4 | 85 | 111 | 105 | 95 | 1 | 29% |
| Longnose Dace | *Rhinichthys cataractae* | 2 | 17 | 17 | 18 | 50 | 102 | 1 | 94 | 31 | 24 | 58 | 2 | 15% |
| Common Shiner | *Luxilus cornutus* | 6 | | 41 | 2 | 71 | 109 | 31 | | 9 | 3 | 6 | 3 | 10% |
| White Sucker | *Catostomus commersoni* | 39 | 4 | 15 | 18 | 7 | | 3 | 70 | 22 | 30 | 27 | 4 | 7% |
| Fallfish | *Semotilus corporalis* | 114 | | | 3 | 35 | 14 | 5 | 44 | | | 22 | 5 | 6% |
| Slimy Sculpin | *Cottus cognatus* | | 35 | 27 | | | | | | 9 | 17 | 12 | 6 | 5% |
| Brook Trout | *Salvelinus fontinalis* | | 19 | 7 | | | | | 18 | 5 | 11 | 10 | 7 | 4% |
| Longnose Sucker | *Catostomus catostomus* | | 11 | 26 | | 11 | 38 | | | | | | 8 | 4% |
| Redbreast Sunfish | *Lepomis auritus* | | | | 2 | | | 10 | | | | | 9 | 3% |
| Atlantic Salmon | *Salmo salar* | | | | | 23 | 42 | | | | | | 10 | 3% |
| Brown Bullhead | *Ameirus nobulosus* | 19 | | 2 | | 1 | | | 13 | | | 1 | 12 | 2% |
| Creek Chub | *Semotilus atromaculatus* | | | 9 | 1 | | | 2 | | | 4 | | 13 | 2% |
| Yellow Perch | *Perca flavescens* | | | | | | | | 33 | | | | 14 | 2% |
| Pumpkinseed | *Lepomis gibbosus* | | | | | 2 | 2 | | 13 | 1 | | 5 | 15 | 2% |
| Golden Shiner | *Notemigonus crysoleucas* | | | 6 | | 9 | 9 | | | | | | 16 | 2% |
| Chain Pickerel | *Esox Niger* | 10 | | | | | 1 | | 3 | | | | 17 | 2% |
| Spottail Shiner | *Notropis hudsonius* | | | | | 2 | 3 | | | | | | 21 | 1% |
| American Eel | *Anguilla rostrata* | | 1 | | | | | | | | | | 22 | 1% |
| **Totals:** | | 194 | 141 | 309 | 68 | 300 | 458 | 56 | 373 | 188 | 194 | 236 | | 1 |

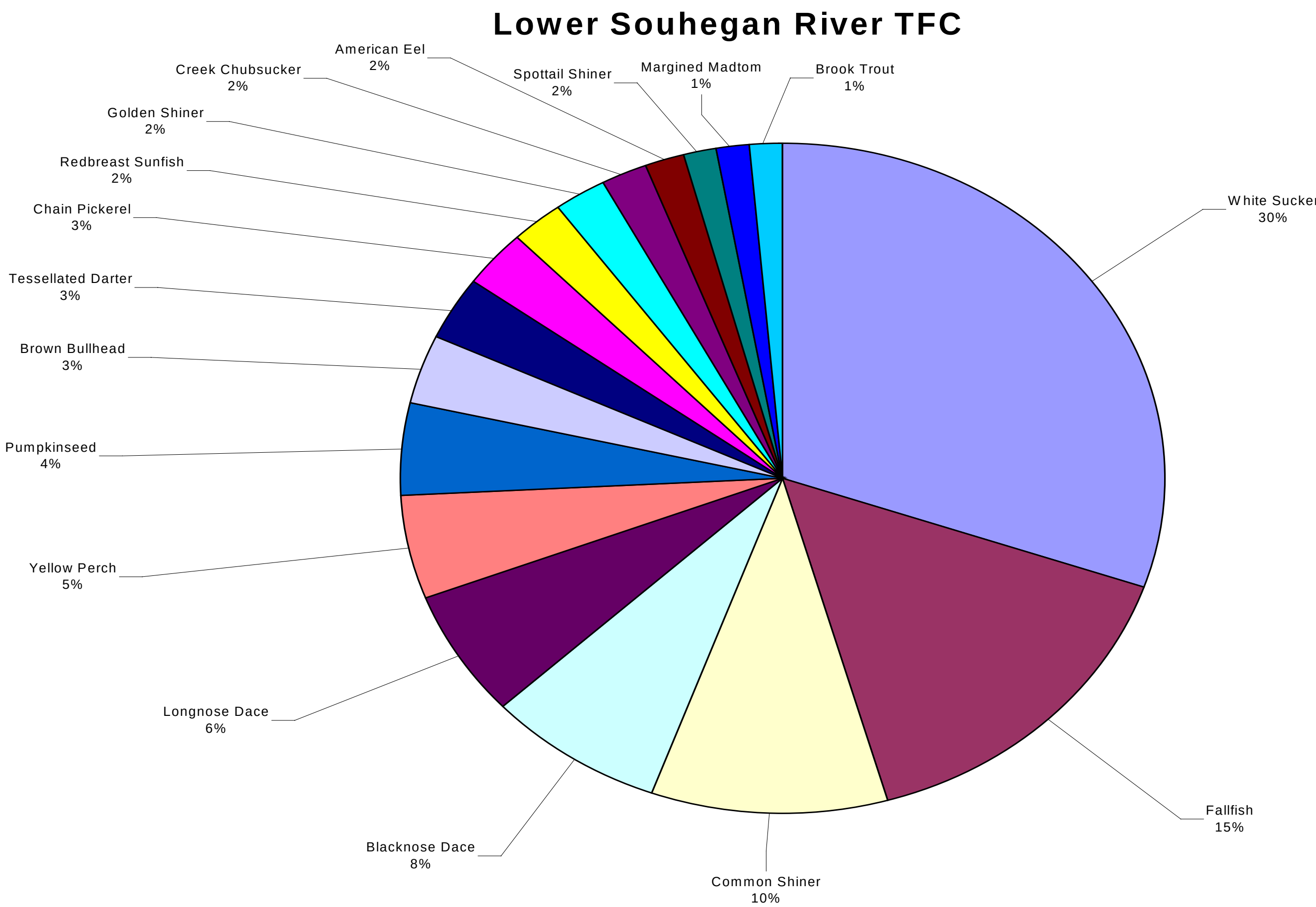


Figure 4. Pie chart representing Target Fish Community for Lower Souhegan River (L-TFC).

Table 4. Lower Souhegan River Target Fish Community species list with mean ranks and expected proportions of species.

| Common Name | Species Name | Quaboag River | Quinnipiac River | Soucook River | Ware River | Willimantic River | Mean Rank | Expected Proportion |
|---|---|---|---|---|---|---|---|---|
| White Sucker | *Catostomus commersoni* | 69 | 625 | 2 | 283 | 1092 | 1 | 30% |
| Fallfish | *Semotilus corporalis* | 14 | 95 | 1 | 227 | 3194 | 2 | 15% |
| Common Shiner | *Luxilus cornutus* | | | 100 | 32 | 1440 | 3 | 10% |
| Blacknose Dace | *Rhinichthys atratulus* | 14 | | 117 | 5 | 557 | 4 | 8% |
| Longnose Dace | *Rhinichthys cataractae* | 69 | 225 | 53 | 70 | | 5 | 6% |
| Yellow Perch | *Perca flavescens* | 193 | 30 | | 203 | 193 | 6 | 5% |
| Pumpkinseed | *Lepomis gibbosus* | 208 | 10 | | 96 | 50 | 7 | 4% |
| Brown Bullhead | *Ameirus nobulosus* | 138 | | 2 | 14 | 2 | 9 | 3% |
| Tessellated Darter | *Etheostoma olmstedi* | | 135 | 2 | | 104 | 10 | 3% |
| Chain Pickerel | *Esox Niger* | 128 | | | 9 | 7 | 11 | 3% |
| Redbreast Sunfish | *Lepomis auritus* | 82 | | | | 150 | 13 | 2% |
| Golden Shiner | *Notemigonus crysoleucas* | 104 | | | 1 | 22 | 14 | 2% |
| Creek Chubsucker | *Erimyzon oblongus* | 91 | | | 9 | | 16 | 2% |
| American Eel | *Anguilla rostrata* | | 75 | 2 | | 21 | 18 | 2% |
| Spottail Shiner | *Notropis hudsonius* | | | 6 | | 16 | 20 | 2% |
| Margined Madtom | *Noturus insignis* | 26 | | | | | 21 | 1% |
| Brook Trout | *Salvelinus fontinalis* | | 5 | 1 | | | 24 | 1% |
| **Totals:** | | 1136 | 1200 | 286 | 949 | 6848 | | 1 |

## Discussion

The target fish communities developed for the Souhegan River, offer a starting point for the comparison of the existing fish community (XFC) of the Souhegan. They also create a tool for the analysis of habitat availability for desired fauna composition. The details of these communities should be reviewed further to ensure that the TFC is indeed indicative of a desired community.

For example tessellated darter was neither listed on the list of expected Souhegan River fish species presented in the IUPOCR report (NAI, 2004) nor was it listed as historically present within the Merrimack River drainage of New Hampshire (Scarola, 1987). We include it in this draft of the L-TFC because of the presence of this species in a sample from the Soucook River, a tributary of the Merrimack River.

Another question is whether some species that are under-represented or even un-represented (e.g. diadromous species) should be included in this model. Bain and Meixler (2000) expressed difficulties involved in the decision to include species such as anadromous species because of "*differing management agency views on feasible long-term actions (e.g., fish passage facilities, dam removal).*" Given the lack of comprehensive historical data it is difficult to make such determinations based on anything other than the current conditions within the quality reference rivers. These rivers, despite their designation as "quality rives", are missing many historically present species of fishes.

Due to U.S. Fish and Wildlife Service efforts to restore Atlantic salmon (*Salmo salar*) and American shad (*Alosa sapidissima*) to the Merrimack River and its tributaries, this issue is of specific importance. Additionally, in our project we plan to use the fish community structure as a biological template, which will help to reconstruct underlying habitat structure in the river. Exclusion of these species could lead therefore to the omission of important elements of the Souhegan River ecosystem and misleading recommendations. This raises the question of whether or not to attempt the simulation of this historical community. One solution would be to take the TFC method one step further through the development of a Reference Fish Community (RFC). A RFC would include all species that existed within the watershed historically but have since been extirpated (e.g. anadromous fishes), and would account for proportional differences of those species that may be currently under-represented, such as brook trout. The expected proportions of these species would be computed using expert-opinion-based ranking within the community. This would allow for the necessary consideration of habitats that are important for the river and maybe critical to future recoveries or re-establishments of these populations.

The Target Fish Communities created here provide a good management target. Both are dominated by fluvial specialists and compared to other models developed for theses regions (Quinebaug River, Housatonic River, Mill River) the community structure looks reasonable. We are expecting minor modification and would like to move into defining the Reference Fish Community as a next step.

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